that conversion, but virtually everything technically related to the television process is imperfect (it is, after all, a system subsampled horizontally, vertically, and temporally). Given all the latent imperfections of the total system this de-interlacing process acquires a proper perspective -- it is a practical solution to solve most of the problems. As to the questions raised about the technical feasibility of incorporating such de-interlacers into a television receiver: the Commissioners have recently seen for themselves a current consumer embodiment of this technology. At the December 12, 1995 *en banc* hearings on DTV, SEL provided and demonstrated a commercially available HDTV home receiver that accepts a 60 Hz interlaced scanned input television signal and displays it at full 60 frame progressive. Again, almost all of the traditional interlace artifacts are removed by de-interlacing at the display. We emphasize that such de-interlacing is today a well-known art -- cost effective, implementable in VLSI, already available in some receivers, and finally, as the Commissioners recently witnessed, it works very well.

SEL is a company heavily involved in the core technologies, and associated businesses, of both television and computing. A central long-term corporate strategy is based on an innovative convergence of our audio-visual technologies (today largely digital) with computing and communications. Interoperability is not a "buzzword" within Sony. It is a central underpinning of all we aspire to bring to the global markets in electronic communications.

There is little to gain by any adoption of a dogmatic stance that seeks to rigidly impress the technical views of one industry on another -- especially as an ill-advised last ditch strategy to derail the superb inter-industry work that dealt squarely with the

progressive-interlace issue (among many others) and produced a consensus standard (on a scale never seen before in the communications industry) for DTV. Clearly, the core priorities, and the technical constraints that bind the television broadcasting industry, are little understood by those presently declaiming against the inclusion of an interlaced format in that splendid standard.

Television engineers, and program producers, are by no means new to the art of digital video and all that it has spawned. They have been digitizing video for more than 30 years. An enormous body of creative experience has been gained. The mixing of live electronic origination in real time with digital character generation, digital computer graphics, and digital film transfers were all incorporated into the fabric of television production long ago. Interoperability among all of these picture-creating media is not a new art. And, it has all been done within the bounds of an interlace-only television environment. Television engineers learned how to properly size computer-created text and graphics for easy viewing, how to properly prefilter such digitally generated signals to minimize Interlace related artifacts, and how to effectively deploy them within the world's 525- and 625-line television systems -- all with a level of artifacts lower than traditional NTSC/PAL/SECAM encoding impairments.

We submit that there is no doomsday scenario here and no catastrophic impairment to the long term progress of Advanced Digital Television services. Interlaced scanning is the ONLY way, at present, to allow the equipment central to HDTV production (especially cameras and recorders) to be implemented at full HDTV spatial resolution within a bandwidth limited environment. Interlaced scanning is the only

current way to facilitate transmission of live television origination at 60 pictures per second, through a very restrictive 6 MHz RF transmission channel.

One day, technology will progress to cost-effective progressive scanning appropriately accommodated within such restricted television systems. But until that day arrives, interlace scanning deserves whole-hearted support and simply must be preserved as a critical component of our flexible new standard It is essential to the timely marketplace acceptance of HDTV, supportive of the expressed desire of the Commission to "encourage the rapid deployment of new telecommunication technologies" (NPRM ¶43).

Finally, to expedite a vigorous and successful marketplace launch, digital HDTV equipment must be affordable while also fully meeting all of the imaging capabilities of the DTV services. It is our view that full 1920 x 1080 spatial resolution must constitute true HDTV at the outset. We believe that the digital HDTV cameras, recorders, switchers to support this will be affordable. The huge decade-long investments made by ourselves and others have finally yielded a mastery over all related core technologies, and now the full capability of digital semiconductor LSI can be brought to bear on implementing a new generation of cost-effective HDTV studio equipment based initially on interlace scanning, and evolving as rapidly as technology allows to full 60 frame progressive scanning.

Therefore, SEL emphatically urges that the use of interlace and progressive scan be included in the mandated standard as only the combination of both can accommodate all types of television programming and other non-television uses.

2. The 60 Hz Transmission Rate

Some in the computer industry continue to argue for a DTV transmission rate higher that the current 60 Hz. Again, they appear oblivious to the fundamental linear relationship between television frame rate and the bandwidth required to sustain that frame rate. Any move to the proposed 72 Hz (or higher) means at least a 20% increase in system bandwidth for the same spatial resolution and line number. But, DTV is confined to operate within a 6 MHz RF channel. Bandwidth is thus a highly precious commodity.

The Grand Alliance system designed the very best compromise that ensured a superb HDTV digital transmission through a very constrained 6 MHz channel. A 20% increase in transmission rate would disturb the careful balance of those other technical parameters crucial to high quality imagery and proper amelioration of numerous artifacts

Nor is 72 Hz (or higher) required for high quality motion portrayal in a DTV system. We know this from the excellent performance of our present 60 Hz based NTSC system. In terms of its capture and portrayal of high speed motion in sports it is the envy of the world.

It is meaningless to argue that a 72 Hz (or higher) frame rate would make the DTV system more interoperable with computer display systems. These systems employ a wide variety of display refresh rates (some already close to 90 Hz). Again, no singular standard exists in the disparate computer industry Widely different viewing conditions determine the plethora of refresh rates employed in an industry that serves countless closed circuit application. The television industry is better served by a singular

field/frame rate. Many considerations led to the consensus on 60 Hz. It is an excellent number -- all things considered.

Contemporary digital technology has facilitated an ability to more distinctly separate television program origination frame rate from television signal transmission rate, and from the ultimate television display refresh rate. Different frame rates (lower than 60 Hz) can be easily accommodated in television program production (witness the 24 fps origination rate of motion picture film, which can be portrayed at 60 Hz in the home receiver for the Grand Alliance/ATSC DTV system).

This digital decoupling of transmission rate from display refresh rate is a powerful flexibility within the ATSC DTV standard. Manufacturers can choose any native display refresh rate they deem to be both functional and competitive -- at various tiers of the DTV receiver hierarchy.

Nor are the interests of the computer industry being ignored. Even before the Grand Alliance system became an ATSC DTV standard, SEL had brought to the marketplace a high-performance computer display (designed and manufactured in our San Diego plant) based largely upon that emerging television standard, but reflective of some specific desires of computer manufacturers (a 28-inch 16:9 screen, 72 Hz refresh rate, 1920 x 1080 square pixel, and full progressive scanning).

The 60 Hz transmission rate is the best compromise to ensure HDTV transmission through the narrow 6 MHz channel and SEL endorses its adoption and mandate as part of the ATSC standard.

3. 16:9 Aspect Ratio:

The U.S. did something no other region of the world attempted in their initial deliberations on an HDTV production standard. It sought input from the motion picture film industry. At the very outset, the SMPTE charged the specially formed HDEP (High Definition Electronic Production) Working Group to meet primarily in Los Angeles—with the expressed goal to include the motion picture industry in the forging of a U.S. HDTV studio origination standard. For eight years this working group wrestled with a task that seemed at times impossible -- to effect reconciliation among widely divergent interests. But they persisted and succeeded beyond most expectations. Los Angeles became the sole meeting location over this protracted period in order to fully engage the film production community. From these extensive discussions the 16:9 aspect ratio emerged. Its own story is well documented in the extensive SMPTE records. The proof of its success and the dramatic climax came when the U.S. delegation persuaded virtually the entire world to support 16:9 for all widescreen television systems (HDTV and SDTV) at the Consultative Committee on International Radiocommunications (CCIR Study Group 11) in 1986.

It seems remarkable, therefore, that more than a decade later, this hard-won compromise is being newly challenged by some in the U.S. film community. There is a further irony here -- in that a creative community who (quite rightfully) seek to be totally unfettered in choosing whatever aspect ratio they wish in contemporary motion picture film origination, should nevertheless be so dogmatic in their insistence that only their choice of a 2:1 aspect ratio should be imposed upon a renaissance television industry

poised to enter an era of deregulation, new creative freedoms, and new digital flexibilities. There is also a curious paradox—in that one of the major reasons the SMPTE HDEP working group firmly supported the 16:9 ratio was that it could accommodate the 4:3 archival treasures (both television and motion picture films) in addition to the variety of widesceen film formats (both archival and current). These treasures include years of classic programs such as "I Love Lucy" and "Gone With The Wind" which richly deserve to be seen and loved by future generations.

Sony Electronics believes 16:9 to be the very best possible unique and singular aspect ratio -- one that properly accommodate the huge vaults of 4:3 film and video programming archives and the continuing random usage of various widescreen film formats. There had to be a compromise on the aspect ratio. Without it, no archival material could be viewed on the new HDTV system.

The continuing worldwide support for 16:9 is a lasting tribute to the genius of this U.S. selection. And again, it must be emphasized -- the U.S. was the only region of the world who sought (as far back as 1983) to embrace both the film and television communities in seeking an HDTV production and display standard. The fruits of this crucial U.S. leadership should not be squandered because of some isolated revisionist thinking that seeks to argue exclusively on the issue of multiple widescreen film image formats, while ignoring the huge reality of extensive libraries of 4:3 program material.

The central preoccupation of those from the film community who commented on aspect ratio is the protection of their creative work. This is understandable. They should not lose sight, however, of the other crucial part of the total "creative" equation—namely,

the issues surrounding the final HDTV presentation to the viewer. Here, it is nowhere so simple as the flexible choice of a film format. Rather, it encompasses a large piece of hardware in which consumers will be expected to invest—namely, an HDTV receiver/display.

HDTV was developed with the specific purpose of radically transforming the home viewing experience from that of today's narrow "window" (the present relatively small 4:3 screen that mostly portrays narrow angle picture content, in turn a consequence of the over-exercising of zoom lenses necessary to curtail picture detail to fill the capabilities of NTSC) to a much larger and wider picture—one that one can fully accommodate all of the extra picture detail that wider-angle shooting can create. In other words, a new television imagery that more fully occupies the human visual system—thus providing a closer approximation to reality This entails a far larger screen area than today's television screen—if the full HDTV viewing experience is to be provided to the viewer. Such screens are costly—regardless of the display technology employed. If they are to come within the reach of the average consumer, television manufacturers, therefore, have no choice but to give very careful consideration to all facets of the design of such a screen. Aspect ratio is a far more critical determinant here than might at first be anticipated.

The cost of screens is proportional to screen area. As screen sizes become larger costs rise with increasing rapidity. Achieving a balance between a screen area—adequate to provide a true HDTV enhanced viewing experience—and rapidly rising costs on larger screens is a core design challenge. As screens get wider, vertical height becomes a more

crucial issue. For a given screen area, vertical height reduces as the screen grows wider. Vertical height is a crucial element in any enhanced viewing experience that attempts to occupy more peripheral vision than today's NTSC imagery. The following experience may serve to illustrate a key dilemma facing television display manufacturers.

When Sony introduced a 28-inch diagonal HDTV studio monitor to the marketplace in 1986 it was soon criticized by the production community (internationally) for its frustratingly low vertical height. While nominally a "large" studio monitor, this 28-inch display subjectively portrayed a small picture—the wide aspect ratio had lowered the height of the image rendering an unsatisfactory overall image size. In addition, this CRT-based monitor was very expensive.

To respond to the creative desires of those pioneering HDTV producers, SEL subsequently introduced a 38-inch diagonal HD studio monitor. This gained high praise for its much improved image portrayal with most comments favorably directed at the increased picture height. However, the cost of this monitor was 45% above that of the 28-inch monitor. Despite our best efforts, we were not able to resolve that manufacturing cost differential (which largely centered around the display tube). The poor sales of this 38-inch monitor (it was a marketing failure despite its acknowledged superb HDTV image portrayal) led to its discontinuation after 5 years. This was a very sobering lesson to us.

CRT-based technology is likely to remain in HDTV studio monitors for many years to come—the picture quality is still superior to all other new display technologies. So this cost issue will be very important to program producers and broadcasters. It is

very likely that new display technologies will be the norm in consumer HDTV receivers and they hold promise of lower costs for larger screens. But, cost sensitivities in the consumer realm are far higher than in the studio or post-production house. Thus, aspect ratio will always remain a critical design factor.

This illustration speaks directly to the issue of aspect ratio. A 2:1 (or 18:9) aspect ratio would greatly exacerbate the very critical vertical height/screen area relationship in a manner that would be prohibitively expensive from both a manufacturer's and consumer's point of view. The 16:9 aspect ratio, quite apart from its original design criteria within SMPTE, actually has proven to be a reasonable trade-off in the vertical height/screen area relationship.

It is through this 16:9 aspect ratio that all program content will be able to be experienced without denying the benefits of cost-effective HDTV to the vast majority of current US television consumers. SEL supports its use within a mandated system.

4. Colorimetry:

Criticisms leveled at the colorimetric specifications contained within the ATSC DTV standard ignore an extensive body of work by SMPTE, ATSC, and the international ITU standards making body. Like most aspects of television engineering, colorimetry is bounded by technical constraints both in image capture (the camera) and image portrayal (the display). The international standard ITU-R-709 is the culmination of a long examination of colorimetry for advanced television. It is the product of real experts in this complex field, from all around the globe. It is a pragmatic standard, in that it ensures

cost-effective implementation with present-day technologies in both real-time imaging and display. It also happens to make those superb pictures that have been seen by many during recent HDTV demonstrations.

The subjective nature of colorimetric issues and the complexity of the topic are fodder for endless technical debate. The debate has been a long one, spanning more that a decade (since SMPTE began its work in 1984). An excellent compromise has been reached. This has gained international consensus as the world's most forward-looking standard. Now is certainly not the time for the U.S. to waver in its staunch support for the major work that it initiated. SEL urges the Commission to place its confidence in the excellent colorimetry standard contained the ATSC DTV standard.

5. Square Pixels:

Square pixels are not at all necessary to make a fully functional digital advanced television system. Indeed, the television industry always operated with non-square pixels. Other digital imperatives led to the rectangular pixel structure adopted in the international 525/625 digital television systems, but it is futile to do any post mortem on the wisdom of this choice. It has not, in any way, impaired our digital television system operations.

Square pixels were incorporated into the standard to accommodate the computer industry, taking a practice that was the norm in computer image processing into the domain of television imaging. Television, while having no technical need for such a pixel structure, incurs no penalty whatever, and indeed, will enjoy a small improvement

in software overhead in image manipulation calculations. This initiative constituted a solid platform to encourage convergence between two disparate industries. It was in this spirit that the television industry embraced square pixels exclusively for the totally new digital HDTV standard.

That inclusion could not, however, be so total with the accompanying 525-line SDTV standard. Here, the television industry was confronted by an old dilemma -- how to transition from an in-place and gigantic marketplace reality to a new standard. The ITU-R-601 4:2:2 digital 525/625 studio origination standard was adopted almost 15 years ago and is ubiquitous worldwide in terms of implementation. Digital SDTV production -- in all 525 and 625 countries -- is an enormous reality today. That fact must be accepted as we transition to digital SDTV transmission. The non-square pixel SDTV standard, based upon ITU-R-601 and the MPEG-2 standard, is vital to an orderly U.S. transition to digital SDTV transmission and must be maintained.

V. THE STANDARD PROMOTES INTEROPERABILITY.

The Commission requests comments on the level of interoperability between the ATSC DTV Standard and alternative media. In particular, the Commission seeks exposure of any critical interoperability problems that might remain (NPRM¶60-64).

SEL participated in all of the work of the ACATS and paid particular attention to the issue of interoperability. We are a manufacturer of professional equipment that services broadcasters, cable and satellite operators. We are a consumer television manufacturer, a video game manufacturer, a computer and computer peripheral

manufacturer, and our sister company, Sony Pictures Entertainment, is a major program content provider for all of the above. Interoperability is thus a central and critical issue within our long-range planning.

SEL believes the work of ACATS, and the practical implementation by the Grand Alliance of a DTV system, to be truly exemplary from the viewpoint of interoperability. It is a model for the world. Most other regions have largely ignored this issue, save perhaps for DVB, but even there computer interests were not a major consideration.

Unfortunately, interoperability debates are almost, by definition, destined to be interminable. It is axiomatic that the different technical communities within the television, computing, and telecommunications industries could never fully agree on any complete definition of interoperability. Their disparate perspectives have been separately forged within huge and fiercely competitive businesses, each propelled by sharply different variants on common electronic technologies. When the multi-dimensional aspects of imagery and sound—with all of their subjective and creative implications—are overlaid upon this technocratic maelstrom only perpetual and lively debate can ensue. The Commission should take careful cognizance of this fact. There is no rational technical resolution to this debate on interoperability *that can fully satisfy all factions.* It therefore reduces to an objective evaluation—on the basis of practical applications—of the many facets of interoperability compromises that have been quite cleverly built into the ATSC DTV standard. A protracted inter-industry working group process closely examined interoperability on the basis of an agreed-to set of eleven characteristics and concluded that the ATSC standard was the best combination of technical elements to

support alternative media. Indeed, the issue of interoperability was central to the choice made in many instances namely progressive scan formats, square pixels, packetized transmission, headers and descriptors and MPEG-2 transport. All requests made by the computer industry were agreed to except for the absolute ban of interlace which would impede present full resolution HDTV live origination and any backward compatibility with SDTV and analog systems. This flexibility exhibited by the Grand Alliance system in accommodating so many different requirements is the best proof that this system should be adopted.

VI. ONCE THE STANDARD IS ADOPTED, ANY CHANGE SHOULD COME THROUGH ADHERENCE TO THE COMMISSION'S ESTABLISHED PROCEDURES.

Any change to an existing technical standard should not be undertaken lightly. This is especially true of a television transmission standard which directly affects the activities of so many industries and consumers. There must be an orderly process for evaluating the necessity for change and the technical, economic and other benefits that would result. Therefore, SEL believes that any necessary change to the standard in the future should follow the Commission's regular procedures.

All other alternatives would undercut the reason for mandating the standard in the first instance -- that of providing the certainty necessary for early adoption and an orderly transition to free over-the-air digital television. Any hint that this standard is so weak that it must be reviewed at a future point certain or within expedited procedures will send a stark and mistaken signal that the standard is somehow flawed.

The Commission's regular procedures for review create an orderly process with opportunity for industry input and consensus gathering. As in this proceeding, the Commission could name an industry Advisory Committee comprised of the experts of that day who would examine the standard in light of the real imperatives of the future and, after thoughtful deliberation of the perceived need, recommend changes which would again be subject to public discourse and review.

There is no way to predict the timing or content of required future changes, but the established procedures of this Commission are the means for effecting them at the appropriate time.

VI. CONCLUSION

For the reasons discussed above, SEL respectfully urges the Commission to mandate the adoption of the recommended ATSC standard comprised of all recommended elements and to require that any future changes be made through adherence to the Commission's established pocedures

Respectfully submitted,

SONY ELECTRONICS INC.

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